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3 NUCLEAR PHYSICS AND COSMOS

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NUCLEAR PHYSICS AND COSMOS *

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by S. N. Vernov

Work on nuclear physics began already in 1940 at the Moscow State University following a recommendation by the academician, S. I. Vavilov. For this purpose, academician D. V. Skobel'tsin and his students were invited to the IGY. Thanks to the organization of the Scientific Research Institute of Nuclear Physics, the IGY became the basis for the conduction of various and even at this time mutually interrelated scientific investigations.

In this short article, it is impossible to review at some length the fundamentals executed at the Institute. Therefore, I will try to bring forth only certain examples.

First, about the particles of highest energies: such particles of billion billions electronvolts exist in the composition of cosmic rays. Thus far, they could not be created artificially. Intensive processes take place at the interaction of these particles with atomic nuclei, whose theoretical explanation has not been given to date. There is basis to expect that a key for the construction of future physics will be found precisely by means of a revealed secret phenomenon taking place at ultra-

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high energies.

Ultra-high energy particles cover enormous distances in cosmic space. Because of this reason, they bring us information about remote regions of the cosmos. Investigations of ultra-high energy particles of cosmic rays are beset with great difficulties, since the number of such particles is very small. Having at his disposition a device of one square meter in dimension, one would have to wait hundreds of years for the fall of one such particle upon it. If, however, the particle is endowed with ultra-high energy, it creates numerous descendants, consisting of many millions and also of billion billions particles. These particle fluxes, or as they are called, broad atmospheric showers, can be collected for comparatively small periods. Thus, for this reason, it is necessary to go beyond the laboratories.

The installation of such a type, designed for the investigation of ultra-high particles of cosmic rays has already been operating in the IGY practically without interruption during many years.

Among many results obtained during the IGY, with the help of this device, one must note first of all the discovery of a sharp variation of the energy spectrum of ultra-high energy particles when the latter exceeds one million billions electronvolts. This implies the presence of two groups in the ultra-high energy particles, having apparently different origins. Particles of the first group, possessing comparatively smaller energy, are born in our galaxy. Particles of the second group, created from particles of highest energies, arrive apparently from other galaxies.

A few words about the investigation of particles of lesser energies: such particles are substantially more numerous in the composition of cosmic rays than those of ultra-high energies. Therefore, not only their descendants can be trapped, but they themselves can be caught in complex devices, allowing to obtain a detailed information concerning the character of their reaction with atomic nuclei. The question arises in the given case of particles, possessing energy in the thousands and ten thousands millions electronvolts. This energy exceeds by one thousand times the maximum energy of particles obtained with the help of contemporary accelerators. Therefore, there is no doubt that the detailed study of the properties of these particles and of the character of their interaction with atomic nuclei strongly advances contemporary physics.

It seems that an insurmountable difficulty stood in the way of utilizing such particles for a long time. No method to measure their energy was then available, but it was devised during the IGY. The ionization calorimeter of Professor M. L. Grigorov allows to measure the energy of particles.

Studying the sources of formation of the different particles, we must reach a conclusion that there exist peculiar "cosmic particle accelerators," in nature. The dimensions of some of them are very great. Others are located over a small surface of the Sun, and at last, there are cosmic accelerators nearer the Earth, whose dimensions are only slightly greater than the diameter of our planet.

As a result of the work obtained in the IGY during the flight of the third Soviet Earth's satellite, the outer radiation belt of the Earth was revealed. Subsequent investigations in the IGY showed that the origin of this region was completely different from that of the inner belt, discovered during the flights of American satellites. It was demonstrated that the action of the "cosmic accelerator" precisely leads to the formation of the outer radiation belt of the Earth. At the present time, the important problem of finding the operational mechanism of this accelerator is being resolved. After the discovery of radiation belts, a series of long-observed phenomena, such as polar aurorae, magnetic storms, certain phenomena in the ionosphere and many others became clarified. The studies of resonant absorption of gamma rays of the so-called Messbauer effect, were broadly set up in the IGY. Atomic nuclei, attached to solid bodies, possess extraordinary properties of emitting and absorbing electromagnetic oscillations---gamma rays without recoiling.

To speak more precisely, this recoiling, known to all of us, by the effect of a firearm at time of firing, of course, does exist. But such conditions are materialized when the recoiling is received by a solid, macroscopic body, whose mass is many million times greater than the mass of the atomic nucleus. In these conditions, a gamma quantum is emitted and absorbed: its energy corresponds precisely to the difference of the energetic levels in the nucleus. Utilizing this phenomenon, the weak electromagnetic fields can be measured, induced in the place where the atomic nucleus is found. Therefore, the atomic nucleus becomes some sort of a probe, tackling the structure of the matter. As a result of the work completed in the IGY, the so-called chemical displacement of the Messbauer line was revealed. This means, therefore, that the atomic nucleus can provide information about the chemical composition of the compound in which the atomic nucleus is found.

*** T H E E N D ***

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		RTR	NEILL	UCLA	
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			ROBBINS		
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